NOTES ON THE INVERTEBRATE FAUNA OF THE DAKOTA FORMATION, WITH DESCRIPTIONS OF NEW MOLLUSCAN FORMS.

[With plate VIII.]

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ALTHOUGH the Dakota formation is of great geographical extent, and, stratigraphically, one of the most clearly defined of the divisions of the North American Upper Cretaceous, comparatively little is known of its contemporary fauna. Of its flora, however, which is a great and varied one, much more is known, and remains of its numerous specific forms are generally used in the paleontological characterization of the formation. Those remains consist largely of angiospermous leaves, and a greater or less number of species have been found in all the districts where the formation has been recognized.*

The discovery of vertebrate remains in Dakota strata was, some years ago, publically announced, but it has since been ascertained that they came from the underlying Jurassic strata. It is, therefore, not yet certain that remains of land animals of any kind have been found within the proper limits of this formation, which fact, in view of the evidence we have of the contemporaneous prevalence of a great and varied land flora, is quite remarkable.

Notwithstanding the great geographical extent of the Dakota formation, only three discoveries of invertebrate remains have, so far as I am aware, been made in its strata. The first of these discoveries was made by Dr. F. V. Hayden in the valley of the Missouri River, at a few localities within a small district which embraces the mouth of the Big Sioux River. The second discovery was made by Prof. B. F. Mudge in Saline County, Kansas, and the third by Prof. L. E. Hicks in Jefferson County, Nebraska.

Those which were discovered by Dr. Hayden are described and figured by Mr. F. B. Meek in Volume IX of the U. S. Geological Survey

*See The Flora of the Dakota Group, by Leo Lesquereux; Monog. XVII, U. S. Geological Survey. Washington: Government Printing Office, 1891. This is a posthumous publication, edited by Prof. F. H. Knowlton.

of the Territories. A part of those discovered by Prof. Mudge are described and figured by Mr. Meek in the volume just mentioned, and a part of them by myself in volume II of the Proceedings of the U. S. National Museum. Those which were discovered by Prof. Hicks are described and figured in this article.

Prof. Hicks made his collection about ten years ago and deposited it in the cabinet of the Nebraska State University in 1885. In that year he referred to it in a paper which he read before the American Association for the Advancement of Science as representing a marine fauna,* but further study showed it to have been of nonmarine origin. The following description of the locality at which Prof. Hicks discovered these fossils has been given me by him:

Jefferson County, Nebraska, 5 miles west of north from Fairbury, about 1 mile from the Little Blue River. The exposure is a comparatively slight one and occurs upon the north side of a deep ravine, about half way up the slope. This ravine opens into Whiskey Run, and the latter empties into Little Blue River.

The Dakota strata at this locality, as is usually the case in all that district, consists of ferruginous sandstone, the fossiliferous layers consisting largely of impure, partly oolitic, limonite. Fragments and masses of these layers constitute the collection made by Prof. Hicks. These specimens contain an abundance of fossil remains, all of which are either vegetal or molluscan, and all are in the condition of natural casts, molds, or imprints. All the molluscan forms which have been recognized are described and figured on following pages. The plant remains embrace well-known Dakota species. The following have been identified by Prof. F. H. Knowlton, the editor of Lesquereux's work on the Dakota flora, already referred to: *Salix meekii*, Newberry, *Diospyrus primæva*, Heer, *Sapindus diversifolius*, Lesquereux, *Magnolia* ———? (probably new), *Platanus primæva*, Lesquereux.

All the specimens of the collection being in the condition of natural casts, imprints, and molds, the greater part of the studies recorded on the following pages, and all the figures on the accompanying plates, have been made from artificial casts taken from the natural molds. Because of this condition of the specimens the studies of all the species which they represent have been far from complete. So much interest, however, naturally attaches to the division of the Dakota fauna which they represent that, notwithstanding their imperfection, I have thought it desirable to publish them. I have also thought it desirable to give a specific name to each form for purposes of convenience in geological studies, rather than as indicating a satisfactory biological classification.

I am indebted to the authorities of the Nebraska State University, through Prof. Erwin H. Barbour, for the opportunity to study and publish this small but interesting collection. All the specimens used in this study are returned to the cabinet of the University at Lincoln,

* Proc. A. A. A. S., vol. 34, pp. 217–219.

together with the artificial casts used in the preparation of the descriptions and figures. A duplicate set of these casts, however, is deposited in the U. S. National Museum at Washington.

Class CONCHIFERA.

Family UNIONIDÆ.

UNIO BARBOURI, new species.

Plate VIII, Figs. 1, 2, 3.

Shell elongate-subelliptical, as viewed laterally, narrowly subelliptical, as viewed vertically, and ovoid as viewed in front. Dorsal margin gently convex, abruptly rounded to the front margin; the latter margin gradually rounded to the broadly convex basal margin; posterior margin abruptly rounded or subangular, its most prominent part being above the midheight of the shell; beaks not prominent, situated near the front, but they are not so nearly terminal as is often the case with Cretaceous species of *Unio*. Cardinal teeth moderately small; lateral teeth slender; postero-dorsal ridge of each valve slightly prominent and ending, as usual, at the most prominent part of the posterior margin. Surface marked by the ordinary lines and imbrications of growth.

Length, when perfect, of the principal specimen from which the foregoing description is drawn, about 75 mm; height, 35 mm; convexity, 25 mm.

All the known specimens of this species being in the condition of natural molds of the exterior and casts of the interior, the foregoing description, and also the figures illustrating it, have been made from the natural casts and from artificial casts taken from the natural molds.

One of the artificial casts shows that the beaks had become considerably eroded, a condition extremely common in the case of living species of *Unio* in the waters of the Mississippi drainage system, but quite uncommon among North American fossil species of *Unio*.

This species has the general shape and aspect of the living *Unio anodontoides* Lea, of the Mississippi drainage system, and it is in all respects a modern type of *Unio*. Indeed, it so nearly resembles some individual varieties of the species just mentioned that it is difficult to choose words which shall diagnose it as specifically different. Still, I think it inexpedient, even from a biological point of view, to apply the name of any living species to a Cretaceous form and, that from a geological point of view, it is especially undesirable to do so.

I have chosen the specific name of this form in honor of Prof. Erwin H. Barbour, of the Nebraska State University.

UNIO, doubtful species.

Plate VIII, figs. 4, 5.

The collection made by Prof. Hicks contains an internal cast of a small specimen of *Unio*, probably a young example, which differs too much

in form and proportions from the one just described to allow its reference to that species. Indeed, it differs so much from the other that it seems to belong to the type of *Unio alatus*, Say. Still, the specimen is too imperfect to allow of a satisfactory specific description, but it is figured on plate VIII for the purpose of giving as complete a representation as possible of the meager fauna of the Dakota formation, as it is now known.

Family CORBULIDÆ.

CORBULA HICKSII, new species.

Plate VIII, figs. 6, 7, 8.

Shell of medium size, elongate-subtrihedral in marginal outline; posterior end prominent and narrow; valves of moderate convexity, not strongly unequal; beaks high and narrow and turning forward; basal margin broadly convex; posterior margin narrowly rounded; posterodorsal margin slightly convex and sloping downward from between the beaks to the narrow posterior end; front margin regularly rounded from the basal margin to the inter-umbonal space; surface marked by the usual distinct lines of growth; hinge having the typical characteristics of *Corbula*.

Length of the largest example in the collection, which is a left valve, 26 mm; height from base to umbo, 16 mm; convexity of the single valve, 6 mm.

The collection contains an abundance of specimens of this species, all of which are in the condition of natural molds and casts. The foregoing description has been made from those molds and casts and from artificial casts taken from some of the natural molds. The figures on plate VIII are drawn from artificial casts.

This form is of the same general type as that of the Laramie *Corbula* to which Mr. Meek gave the name *C. crassitelliformis*, but it is somewhat more gibbous and also broader in front. The specific name is given in honor of Prof. L. E. Hicks, its discoverer.

Class GASTEROPODA.

Family CERIPHASIIDÆ.

GONIOBASIS JEFFERSONENSIS, new species.

Plate VIII, fig. 9.

Shell small, slender, sides of the spire approximately straight; volutions apparently about 10 in number, gradually increasing in size from the apex to the front; sides of the volutions nearly straight or flat, thus forming the nearly straight sides of the spire; suture linear; surface nearly or quite smooth.

Length of the only specimen discovered, 13 mm; breadth of the last volution, 5 mm.

This species is represented by only a single, somewhat imperfect, natural mold of the exterior of the shell, and which does not show the character of the aperture. It is therefore referred to *Goniobasis* because of its external form and features. It bears a general resemblance to *G. macilenta* White, of the Bear River formation, but it differs in lacking certain of the surface markings of that species.

GONIOBASIS, doubtful species.

Plate VIII, fig. 10.

Another specimen, evidently referable to *Goniobasis*, was found associated with the foregoing. It resembles that species in certain respects, but the apical angle is considerably greater and the shell is therefore less slender. It possibly belongs to the same species with the foregoing, but I am inclined to regard it as representing another form.

Family MELANIIDÆ.

PYRGULIFERA MEEKIII, new species.

Plate, VIII, fig. 13.

The collection contains a single specimen, in the condition of a natural mold, which I have little, if any, doubt represents a species of *Pyrgulifera*. The form and character of the aperture are not shown, but the surface features agree well with those of typical species of that genus, and they are much like those of some individual varieties of *P. humerosa* which were found by Mr. T. W. Stanton in western Wyoming. The volutions, however, are more regularly convex, and the revolving lines finer and more numerous than I have found them to be on any specimens of *P. humerosa*. I therefore give it a new specific name, selecting that of the founder of the genus.

The discovery of *Pyrgulifera* in the Dakota formation is of special interest, not only because that genus has not hitherto been found in any other North American formation than the Bear River, but because that formation is believed to be of nearly, if not quite, the same age as the Dakota.

Family VIVIPARIDÆ.

VIVIPARUS HICKSII, new species.

Plate VIII, figs. 11, 12.

The collection contains three or four imperfect natural molds of a small species of *Viviparus*, artificial casts of two of which are figured on plate VIII. The species is a little more elongate, and the spire more acute, than is usual with *Viviparus*, but a portion of the aperture shown by one of the specimens indicates that it was like that of typical forms of that genus.

Concluding remarks.—It is true that the collection of invertebrate fossils described in this article does not add materially to our knowledge of biological forms, but in several respects it possesses unusual interest. It is, as has already been mentioned, one of only three collections of invertebrate remains that have been made from the Dakota formation, the strata of which we have abundant evidence to believe originally occupied many thousands of square miles. It indicates more distinctly than any previously discovered facts have done, the nonmarine character of that formation. It embraces four genera which have never before been recognized in collections from its strata. Although that formation lies at the base of the Upper Cretaceous series, a majority of the species which this collection contains belong to genera representatives of which are among the characteristic members of the molluscan fauna now living in the waters of the Mississippi drainage system.

Of the few species that were discovered by Dr. Hayden a part belong to genera which are generally regarded as indicating a marine habitat, a part are such forms as usually inhabit estuarine or other brackish waters, and one was referred by Mr. Meek, who described these fossils,* to the genus *Margaritana*. I have no reason to doubt that this species belongs to the Unionidæ, but the type specimens do not satisfactorily show the hinge structure and other features upon the modification of which the different genera of that family are established.

Dr. Hayden did not find the forms which have just been mentioned as indicating a marine habitat in immediate association with the shell which Mr. Meek referred to *Margaritana*, its only associate having been a form which he referred to *Cyrena*. According to our present knowledge of the habitat of the different molluscan genera the association of *Margaritana* and *Cyrena* is incongruous, because the former genus is never found living in saline waters, and the latter never in fresh. I think, however, that the shell referred to *Cyrena* by Mr. Meek may be properly referred to *Corbicula*, the shell characteristics of which genus are so nearly like those of *Cyrena* that it is often difficult or impossible to diagnose them as different in the fossil condition. Species of *Corbicula* are not unfrequently found living in fresh waters, and we have abundant evidence that fossil, if not living, forms of *Unio* and *Corbicula* lived and thrived together. I therefore regard it as reasonable to infer that the Dakota strata in which the two species referred to were discovered were deposited in fresh, or at most, in brackish waters. The discovery of remains of a couple of species of characteristic Dakota plants commingled with these fossil molluscan forms leaves little or no room for question as to the Dakota age of those strata. I have also little doubt that the layers from which came the other molluscan forms discovered by Dr. Hayden in the district just mentioned are near the

* For descriptions and figures of these species, see Vol. IX, U. S. Geol. Surv. Terr., pl. 1, pp. 92, 114, 159, 206, 251.

top of the formation, and that they lived in waters which were then changing to the marine condition which prevailed during the succeeding Colorado epoch.*

The invertebrate species collected by Prof. Mudge in Saline County, Kans., consist wholly of forms which are regarded as indicating a marine habitat, but they are all such as are generally understood to indicate a littoral, or at least a shallow-water, condition. They were described by Mr. Meek and myself, respectively.† I have never personally examined the stratigraphy of Saline County, Kans., but I accepted Prof. Mudge's identification of the Dakota formation there when I published the description of the species referred to, and I have since expressed the opinion that the formation changes from a nonmarine to a marine condition in its southward and southeastward extension.‡

Although the generic characteristics of all the forms contained in the collection of Prof. Hicks are not well shown by the specimens, I have no reason to doubt the generic identity of any of them as indicated by the names applied to them respectively in the foregoing descriptions. I therefore regard the collection as unmistakably indicating a nonmarine origin for the strata from which it was made. Indeed, I think the character of the collection as a whole indicates a purely fresh-water origin. This opinion is supported by the following facts: Of the five genera represented in the collection, representatives of three of them, namely, *Unio*, *Goniobasis*, and *Viviparus*, have never been found living in any other than fresh waters. It is true that species of *Corbula* are usually found in saline waters, and often in those of full marine saltness; but it is also true that living species of that genus sometimes range into fresh waters, and the fossil species have frequently been found associated with *Unio*, *Goniobasis*, and *Viviparus*. The fossil faunal associates of *Pyrgulifera* usually indicate a brackish-water condition, but the type species of the genus, while sometimes found commingled with shells of *Ostrea*, is oftener found associated with such fresh-water forms as *Unio*, *Viviparus*, *Campeloma*, etc. Moreover, the only known living species of the genus inhabit fresh waters.

The general prevalence of land plants in the strata of the Dakota formation is also an indication of its nonmarine origin, as is the general absence of marine remains. Indeed, the only discoveries of fossil remains in Dakota strata which indicate a saline condition of the waters in which they were deposited were made along a part of, or near, the eastern border of the formation.

I do not think it is fully proved that the bulk of that portion of the formation which occurs in the Missouri River valley in the vicinity of

* These remarks are based upon my recollection of a personal statement made to me by Dr. Hayden.

† Vol. IX, U. S. Geol. Surv. Terr., pl. 2, pp. 80, 92, 109, 120, 163, 164, 170, 174, 195, 202, 253, 300, and 333; Proc. U. S. Nat. Museum, vol. 2, pl. 5, pp. 295, 296.

‡ See Bull. U. S. Geol. Survey, No. 82, p. 122.

the mouth of the Big Sioux River was deposited in saline waters, but there is no reason for questioning the marine origin of the collections made by Prof. Mudge in Saline County, Kans. I have no reason to doubt that the Kansas deposit holds the same stratigraphical position in the Cretaceous series as does the Dakota formation, nor do I know of any reason to doubt that it merges horizontally into the Dakota. Still, I am disposed to exclude those Kansas deposits and their southern and southeastern marine equivalents, when discussing the fauna of the Dakota formation proper. Indeed, I think it is to be expected that should any invertebrate remains be found in any of the Dakota strata which are known to prevail in the great region westward and northwestward from eastern Kansas and Nebraska, they will be such as indicate a fresh-water habitat.

EXPLANATION OF PLATE VIII.

Unio barbouri, p. 133.

Fig. 1. Side view of an artificial cast from a natural mold.
Fig. 2. Dorsal view of the same specimen.
Fig. 3. Side view of an artificial mold of a natural cast of a right valve of another specimen of the same species.

Unio (doubtful species), p. 133.

Fig. 4. Side view of a natural cast of the interior of the shell.
Fig. 5. Dorsal view of the same specimen.

Corbula hicksii, p. 134.

Fig. 6. Side view of the left valve; an artificial cast from a natural mold.
Fig. 7. Dorsal view of the same specimen.
Fig. 8. Front view of another specimen; also an artificial cast of a natural mold.

Goniobasis jeffersonensis, p. 134.

Fig. 9. Side view of an artificial cast of a natural mold.

Goniobasis (doubtful species), p. 135.

Fig 10. Side view of an artificial cast of a natural mold.

Viviparus hicksii, p. 135.

Fig. 11. Side view of an artificial cast of a natural mold.
Fig. 12. Side view of another similar cast.

Pyrgulifera meekii, p. 135.

Fig. 13. Side view of an artificial cast of a natural mold.

All the figures on this plate are of natural size except fig. 9, which is slightly enlarged.